NASA Technical Memorandum 81367

ANNUAL REPORT ON RESEARCH AND TECHNOLOGY

FY 1981

NASA
National Aeronautics and
Space Administration

Hugh L. Dryden Flight Research Center
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DRYDEN FLIGHT RESEARCH CENTER ANNUAL REPORT ON RESEARCH AND TECHNOLOGY ACCOMPLISHMENTS

FY 1981

INTRODUCTION

This report highlights the research and technology (R&T) accomplishments of the Dryden Flight Research Center in FY 1981. Items in the report are arranged under the four NASA Program Offices that sponsor the R&T activities, and items within the Office of Aeronautics and Space Technology Program are arranged according to the agencywide Research and Technology Objectives and Plans (RTOP) work breakdown structure. Accomplishments in specific areas can be identified through use of the Table of Contents.

The Dryden Flight Research Center is primarily engaged in conducting flight research into vehicle, systems, piloting, and operational problems. Dryden develops or modifies both piloted and remotely piloted aircraft where necessary for performing flight research. Many Dryden programs are conducted jointly with other NASA installations or government agencies. Dryden also performs or sponsors supporting research in instrumentation, flight test techniques, piloting, flight systems, guidance, communications, crew functions, and air vehicles.

FY 1981 has been an active and productive year at Dryden, with activities ranging from support of the space shuttle program to conducting a wide variety of aeronautics programs. The highlight of the year was the historic first landing of the space shuttle Columbia, which landed at Dryden on April 14. Preliminary stability and control derivatives were determined for the orbiter at hypersonic speeds from the data obtained during re-entry. The shuttle tile tests, spin research vehicle nose shapes flight investigation, envelope expansion flights for the Ames tilt rotor research aircraft, and the AD-1 oblique wing programs were all successfully completed in FY 1981. The KC-135 winglet program was also completed; the results were presented at a program review held at Dryden on September 16. The results of that and of other Dryden R&T work were published in technical reports, papers, and articles listed at the end of this volume. A summary of the R&T flight activities also appears at the end of the volume.

The Dryden Flight Research Center will be consolidated with the Ames Research Center as of October 1, 1981. Future R&T accomplishments at the Dryden Facility will be included as part of the Ames report. Additional information regarding items in this report can be obtained by dialing (805) 258-3311 and asking for the author's Dryden extension. (Telephone users with access to the Federal Telecommunications System (FTS) may dial the extension preceded by 984-8.) Request for additional copies of this report should be referred to John Gibbons, ext. 342.

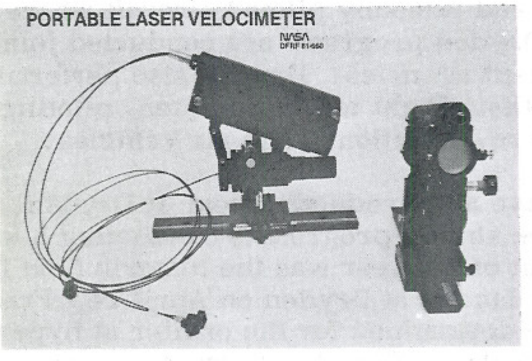
OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICS RESEARCH AND TECHNOLOGY BASE

Aerodynamics Research and Technology

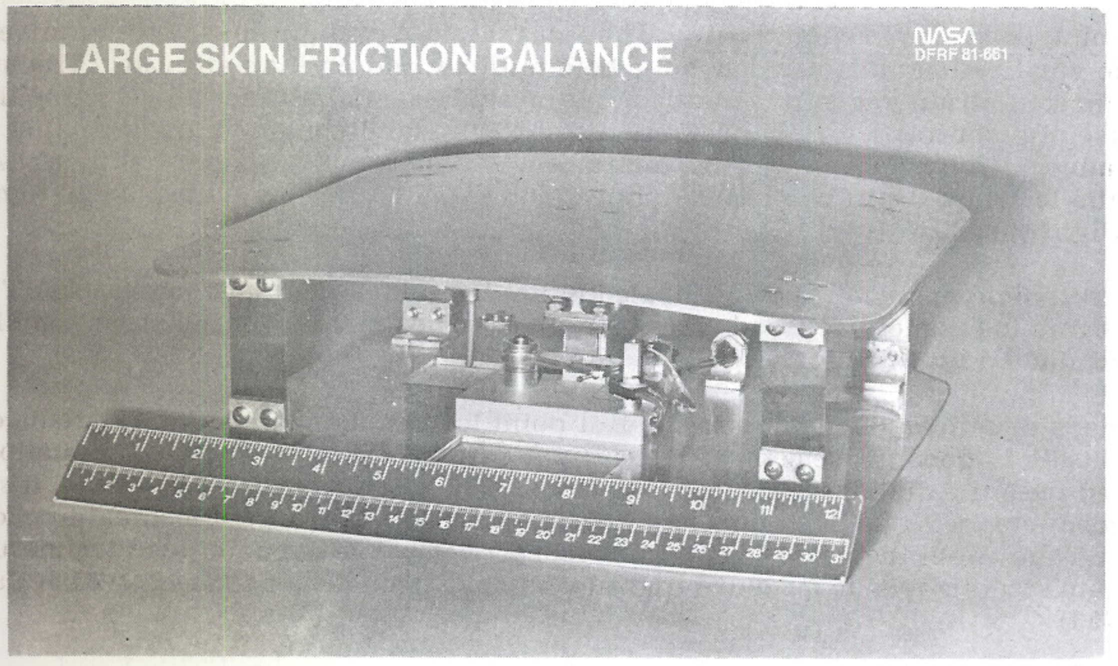
Laser Applications to Flight Testing.— The objective of this effort is to develop optical tools for measuring fluid flow parameters in flight. Present methods of obtaining such information depend on direct contact instrumentation, which disturbs the fluid being measured. In many instances the fluid flow field is too hostile for inserting instrumentation, the region of interest is inaccessible, or the flow field is too complex for conventional measurement techniques to be adequate.

A portable laser velocimeter developed by Boeing Commercial Airplane Company has been successfully lab tested at Dryden. The device is scheduled to be flight tested on the JetStar airplane later this year. Data from these tests will be useful in evaluating the potential of optical flight research tools. (Robert Curry, ext. 534)



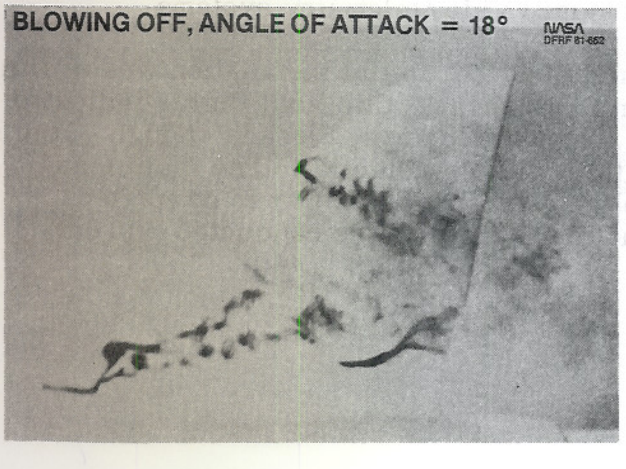
Large Force Balance.— A large skin friction balance is being developed to investigate the effects of such surface discontinuities as rivet heads, lap joints, surface roughness, and gaps. Both displacement and nulling friction balances have been used in wind tunnels and flight for many years. The small size of these balances, however, has limited their usefulness in the determination of roughness drag. The present effort allows for the extension of existing excrescence drag values to the Mach numbers and Reynolds numbers representative of present and future high performance cruise airplanes.

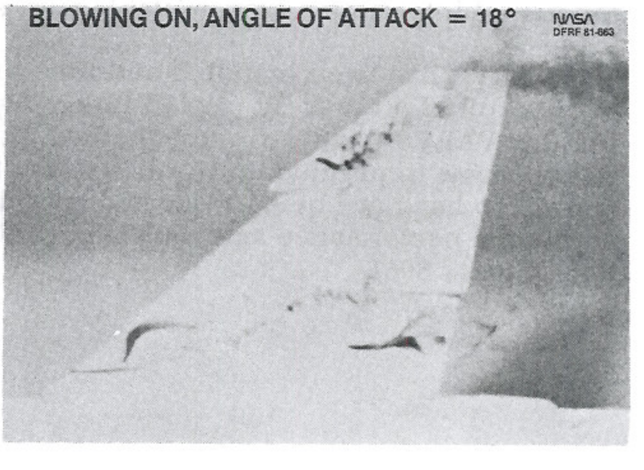
A prototype balance has been completed and is undergoing environmental and calibration testing. Flight tests of the balance are planned for FY 1982. (Robert Meyer, ext. 379)



Spanwise Blowing.— Design concepts that take advantage of vortex lift can substantially improve the maneuverability of fighter aircraft. One of these concepts, spanwise blowing, uses a spanwise jet of air just above the wing's upper surface to stabilize and maintain the wing leading-edge vortex. Wind tunnel tests have indicated that this increases both the angle of attack and spanwise location at which the wing leading-edge vortex separates from the wing and trails downstream. The result is an increase in available lift, a decrease in induced drag, and an extension of the linear pitching-moment range; hence, an overall improvement in maneuverability. In addition, model tests have shown a delayed wing buffet onset and improved lateral-directional stability.

Water tunnel flow visualization studies which make visible natural vortex flow patterns were made in support of wind tunnel tests and are reported in NASA CR-163096. (David Lux, ext. 175)





Materials and Structures Research and Technology

B-1 Point Load Calibration Test.— The measurement of flight loads is a requirement for the verification of design loads for both military and civilian aircraft. The use of calibrated strain gages to perform these measurements has become very popular. The use of point loads for calibration, instead of large distributed loadings, has been advocated by NASA and some airframe contractors. Doubts persist that results from the low-load-level point load calibration can be accurately extrapolated to high-load flight cases.

B-1 air vehicle number 2 was calibrated using the distributed load approach. To investigate the issue discussed above, a point load calibration of the same vehicle was conducted by Dryden.

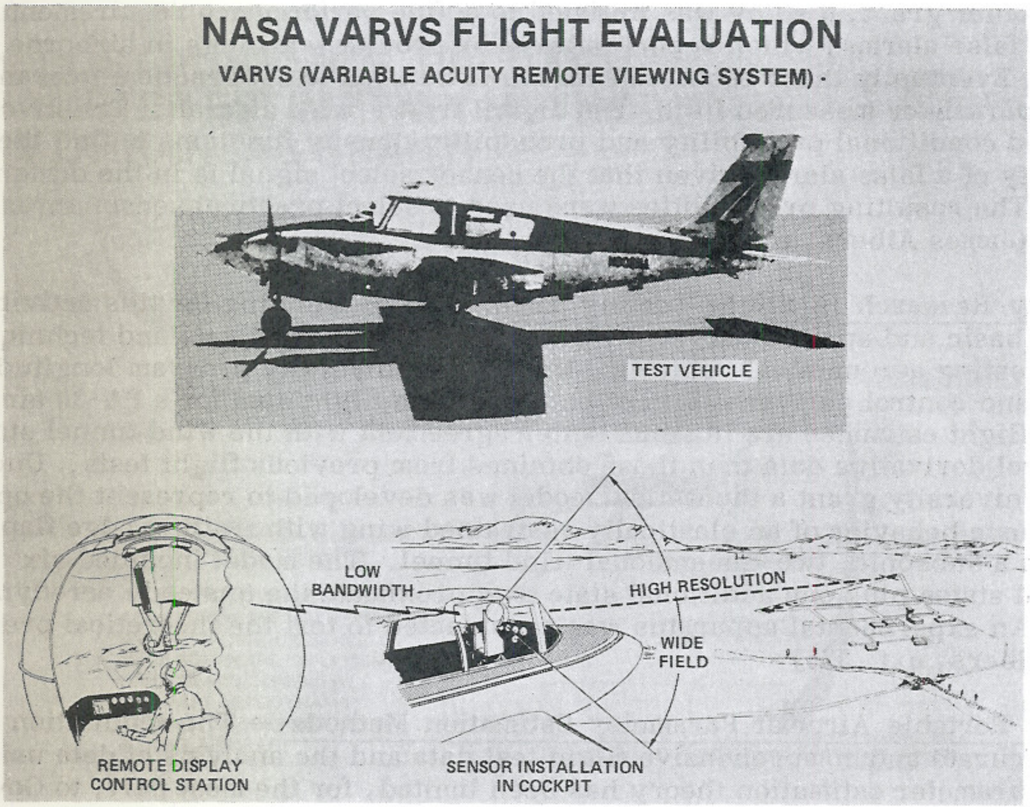
The loads equations derived from the B-1 point load calibration test data produced flight loads in good agreement with the flight data produced by the loads equations derived from the distributed proof load tests. The B-1 point load calibration test was conducted with far less time and expense than the distributed load calibration tests. Thus, both the accuracy and the economy of using the point load technique to calibrate strain gages to measure flight loads have been demonstrated. (Alan Carter, ext. 453)

Human Factors Research and Technology

Remote Piloting Procedures.— While techniques for the remote operation of aircraft have evolved to a high level within NASA, two major problems remain. First, pilot workload during approach and landing is extremely high because of the limited visual information available from standard video systems. Second, these same limitations preclude any long-distance flights because visual restrictions make spatial orientation very difficult.

Both of these problems can be addressed with a wide-angle system if a reasonable bandwidth-resolution tradeoff can be obtained. A variable-acuity remote viewing system (VARVS) is being evaluated as an answer. The VARVS allows a nearly hemispheric (160°) field of view to enable pilots to use their motion-sensitive peripheral vision. The aspheric lens system creates a varying focus across the field of view, permitting a high-resolution 20° cone about the forward visual axis. This combination of low resolution/wide angle and high resolution/narrow angle maximizes the visual information transmittable with standard video telemetry systems.

The VARVS has been installed and functionally tested. Initial installation was within the cockpit of a remotely piloted Piper Twin Commanche. Checkout flights indicated that the VARVS gave definite benefits, but aircraft structures blocked enough of the field of view to preclude full realization of the system's potential. The input lens and video head are being relocated outside the aircraft. When this is completed, additional performance and workload evaluation flights will be conducted. (Terry Rezek, ext. 606)



Multidisciplinary Research

Fund for Independent Research.— The fund for independent research supports basic investigations by universities of new technology in fundamental areas of science and engineering related to the flight of aeronautical vehicles. In FY 1981 the areas of investigation included 1) modeling and control, 2) thrust measurement during flight, and 3) sensor redundancy management.

Under one university grant unsteady aerodynamic theory was developed which has applications to active aeroelastic control concepts, such as flutter control and gust alleviation. The equations of motion of a typical three-degree-of-freedom airfoil section in two-dimensional incompressible flow served as the basis for the study. The exact transient response of airfoil forces to flap motions and gusts at several speeds were determined. The equations of motion were extended to the compressible case which has applications to adaptive control.

Under another university grant, the calculation and measurement techniques used for the determination of thrust during flight were reviewed and examined. The relative sensitivities of the parameters used in the thrust equations for two gas generator techniques were determined. The force-measuring transducers used for the measurement of thrust were updated.

Under another grant, a study was initiated to define performance requirements for detecting false alarms, which report failures or provide warnings in airborne systems. Eventually these requirements are to be used to set practical tolerances for each parameter measured in the F-8 digital fly-by-wire aircraft. The investigator used conditional probability and probability density functions to find the probability of a false alarm, given that the sensor select signal is in the domain of failure. The resulting probabilities were used to select practical sensor threshold values. (James Albers, ext. 375)

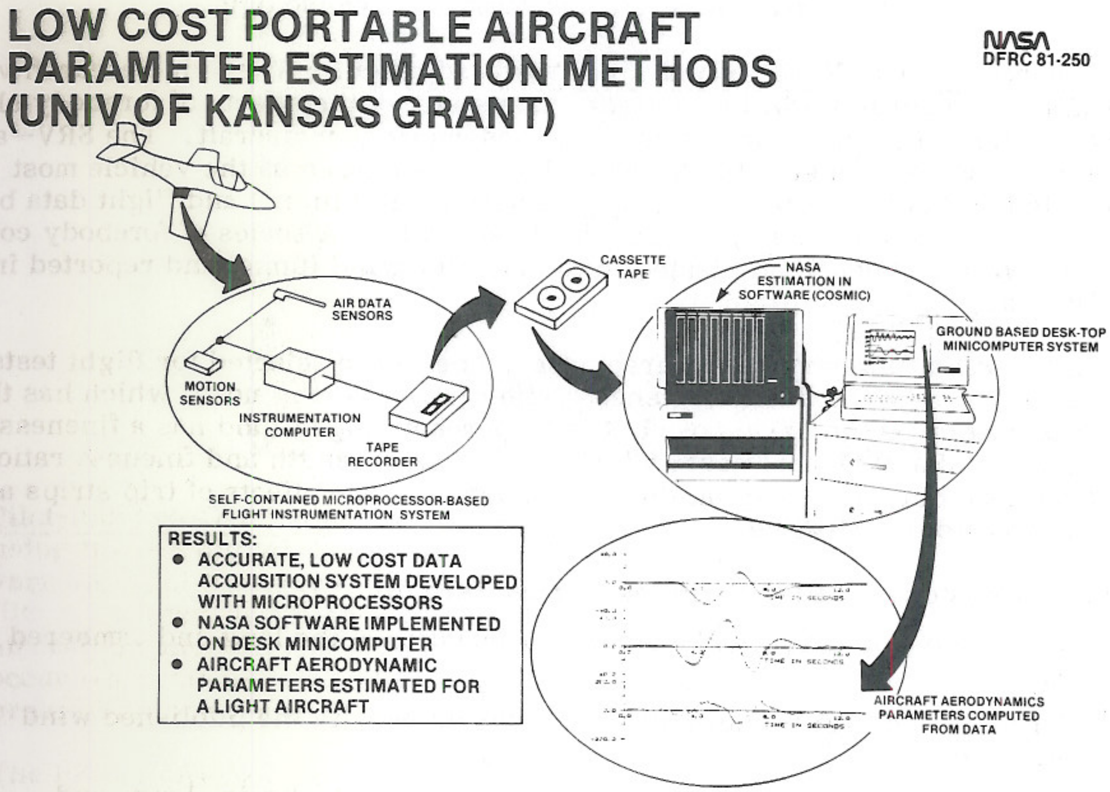
University Research in Flight Testing Techniques.— Funding for this activity supports basic and applied university research related to methods and techniques of flight testing aeronautical vehicles. Under one university program longitudinal stability and control derivatives were obtained from flight data for a PA-30 aircraft. The new flight estimates are in much better agreement with the wind tunnel stability and control derivative data than those obtained from previous flight tests. Under another university grant a theoretical model was developed to represent the open-loop dynamic behavior of an elastically restrained wing with trailing edge flap control in a subsonic, two-dimensional wind tunnel. The model included six structural states plus one additional state to approximate the unsteady aerodynamic effects. An experimental apparatus was constructed to test the theoretical predictions. (James Albers, ext. 375)

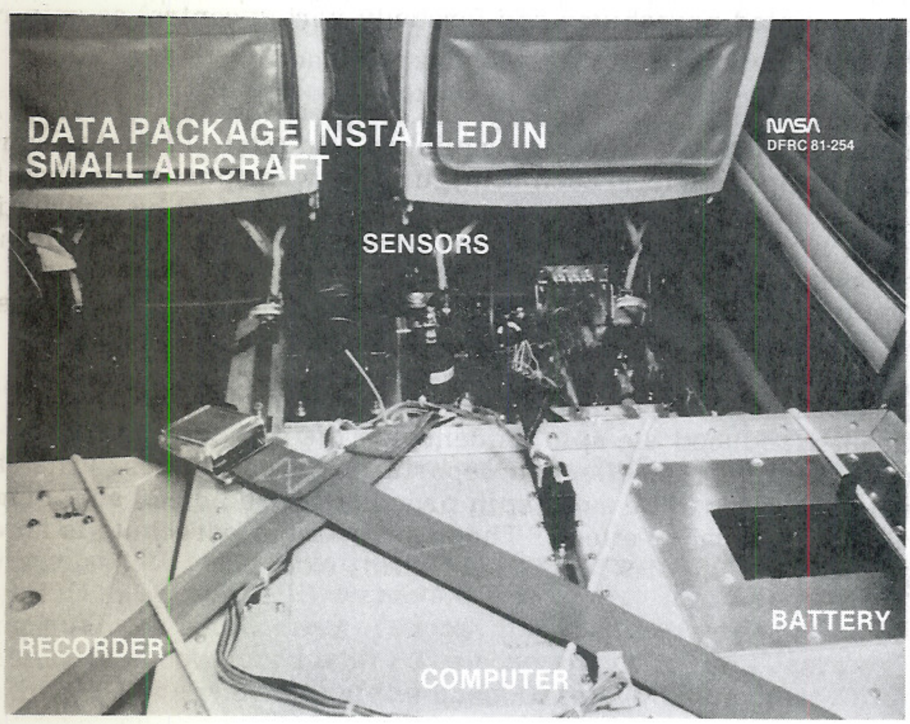
Low Cost Portable Aircraft Parameter Estimation Methods.— The acquisition of highly accurate and comprehensive flight test data and the analysis of data using modern parameter estimation theory has been limited, for the most part, to Government agencies and the larger aircraft manufacturers by the high cost and complexities of available systems. Recent advances in the technologies of transducers and mini-computers has brought the cost and complexity within the capability of universities and small aircraft manufacturers while achieving a reduction in size as well.

Under a grant to the University of Kansas, a simple, low cost, and accurate flight test package has been developed utilizing microprocessors. Data obtained with this system have been analyzed using modern estimation theory on a minicomputer. The overall concept is illustrated in the first figure.

The data acquisition package is self-contained with the exception of a few transducers mounted to the airframe. The second figure shows the package strapped into a test airplane. This system is portable and can be mounted in any airplane with a passenger seat or equivalent baggage area.

The data analysis system is approximately 50 percent complete. Early results from this system indicate that it is capable of producing results equivalent to the older, more complex systems. The application of powerful NASA software to a desk-top minicomputer system will also broaden the utility of and user community for this methodology. (Neil Matheny, ext. 606)


LOW COST PORTABLE AIRCRAFT PARAMETER ESTIMATION METHODS (UNIV OF KANSAS GRANT)
NASA
DFRC 81-250
AIR DATA SENSORS
MOTION SENSORS
INSTRUMENTATION COMPUTER
TAPE RECORDER
SELF-CONTAINED MICROPROCESSOR-BASED FLIGHT INSTRUMENTATION SYSTEM
CASSETTE TAPE
NASA ESTIMATION IN SOFTWARE (COSMIC)
GROUND BASED DESK-TOP MINICOMPUTER SYSTEM
AIRCRAFT AERODYNAMICS PARAMETERS COMPUTED FROM DATA
RESULTS:
● ACCURATE, LOW COST DATA ACQUISITION SYSTEM DEVELOPED WITH MICROPROCESSORS
● NASA SOFTWARE IMPLEMENTED ON DESK MINICOMPUTER
● AIRCRAFT AERODYNAMIC PARAMETERS ESTIMATED FOR A LIGHT AIRCRAFT


DATA PACKAGE INSTALLED IN SMALL AIRCRAFT
NASA
DFRC 81-254
SENSORS
RECORDER
COMPUTER
BATTERY

Spin Research Vehicle Nose Shapes Flight Investigation.— The spin research vehicle (SRV) nose shape flight investigation is a study of the effects of forebody shape on the departure and spin characteristics of modern fighter aircraft. The SRV—a 3/8-scale unpowered model of the F-15 airplane—was chosen as the vehicle most appropriate for this test series. The large existing wind tunnel and flight data base for this configuration was a major factor in its selection. A series of forebody configurations were developed and tested in the Langley wind tunnel and reported in NASA TP-1592.

Based on the wind tunnel results, three nose shapes were selected for flight tests: the basic F-15 nose (which has a fineness ratio of 2.3), a long nose, which has the same cross section as the basic nose but is 50 percent longer (and has a fineness ratio of 3.5), and a cambered nose, which has the same length and fineness ratio as the long nose but has a cusp on the lower surface. The effects of trip strips and strakes were also investigated.

The primary objectives of the flight test series were to:

1. Evaluate in flight the stall/spin characteristics of the long and cambered forebodies,

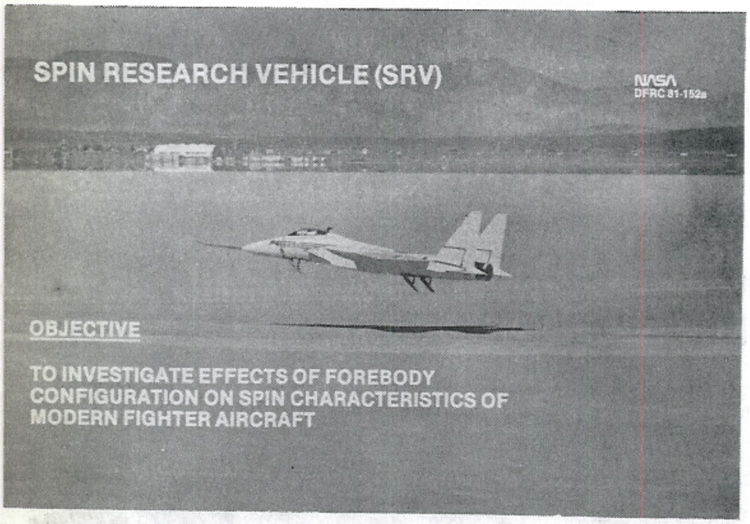
2. Correlate the flight-determined characteristics with the published wind tunnel data, and

3. Compare the flight determined characteristics of the basic, long, and cambered noses.

The secondary objectives were to 1) obtain forebody pressure distribution data and 2) evaluate nose-mounted parachutes and forebody vortex control as spin recovery and prevention devices, respectively.

The flight tests were initiated in February and completed in July of 1981. All primary and secondary objectives were accomplished. In total, 17 flights were flown with the two new configurations. Each configuration was spun on its first flight. Three flights were flown to investigate forebody vortex control by exhausting high pressure nitrogen into the asymmetric vortex formed by the long nose. The complete forebody vortex control system was fabricated, installed, and flight tested during the last month of the tests. Flight tests involving configuration changes of this magnitude and rapidity are possible only with an unmanned vehicle.

A preliminary assessment of the flight data indicates the following results. The strakes significantly reduced the spin tendency on the standard and long noses. The nose boom has a noticeable effect on departure characteristics. The cambered nose configuration appears to be more spin prone than predicted, a tendency which may reflect a Reynolds number effect. The nose-mounted parachute is an effective spin recovery device for the SRV. (Donald Gatlin, ext. 195)



Pilot-Induced-Oscillation Suppression Filtering.— Flight tests were conducted using the F-8 digital fly-by-wire (DFBW) aircraft and the USAF/Calspan NT-33A variable stability aircraft to evaluate the pilot-induced oscillation (PIO) suppressor filter, a system designed to eliminate uncontrolled aircraft motions induced by pilot/aircraft or pilot-control system interactions. These uncontrolled motions generally occur when the pilot workload is very high. Tracking, air-to-air refueling, and precision landing are all tasks which may tend to provoke PIO's.

The PIO suppressor filters examined in these two programs are direct descendants of the filter designed by Dryden engineers for the space shuttle after PIO tendencies were noted in the approach and landing test program.

The F-8 DFBW experiment consisted of two filters with 25 gain configurations. The filters were evaluated in close trail formation, simulating the air-to-air refueling task. The NT-33A experiment consisted of five aircraft configurations, ranging from non-PIO-prone to quite PIO-prone, and two filters with various gain configurations, based on the F-8 DFBW filters. In total, 27 aircraft/filter combinations were evaluated in a precision landing task.

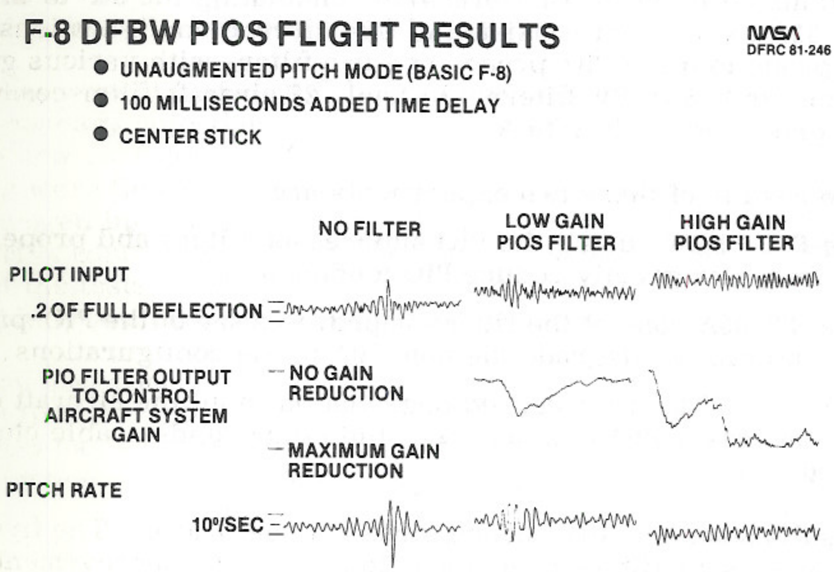
In general, the results of these two experiments are:

1. For the F-8 DFBW, using the PIO suppressor filters and proper gain selection can remove or greatly reduce PIO tendencies.

2. For the NT-33A, one of the filters improved some of the PIO-prone aircraft configurations and did not degrade the non-PIO-prone configurations.

3. The other NT-33A filter caused degradation in all the aircraft configurations evaluated; in some cases PIO was not seen, but other, undesirable characteristics were introduced.

From these results some tentative conclusions may be drawn. The first is that although PIO suppressor filters have a role to play in the improvement of aircraft handling qualities and control systems, they can provide only a partial solution to the difficulties encountered with PIO-prone aircraft. The best procedure for eliminating PIO is a redesign of the basic flight control system. However, when cost and time constraints make this impossible, PIO suppressor filters can be an effective alternative. Nevertheless, careful evaluation and testing will be necessary to determine the best filter for any particular aircraft, since, as seen with the NT-33A, the wrong filter can be worse than no filter at all. (Mary Shafer, ext. 606)



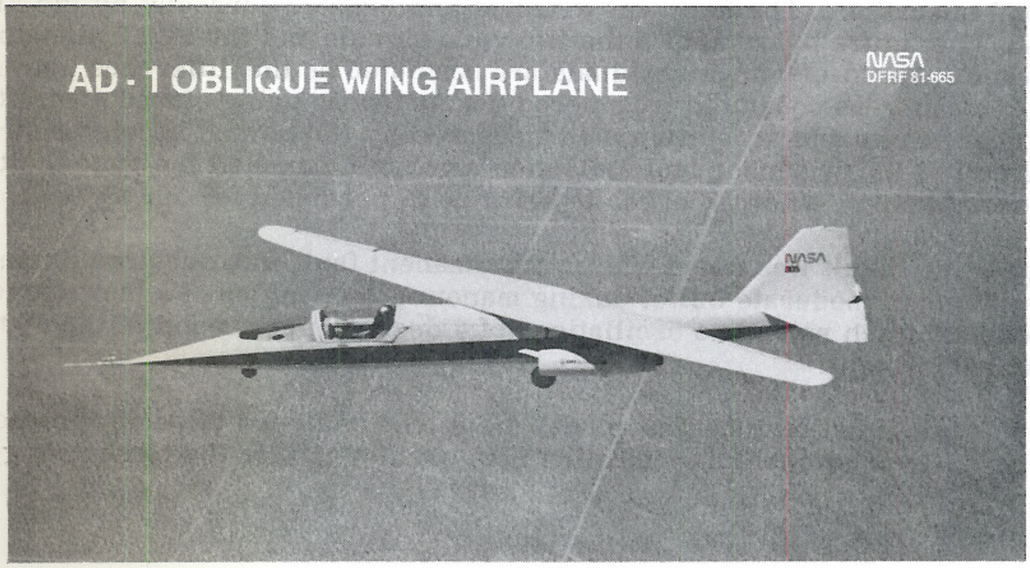
AD-1 Oblique Wing Program.— Flight tests of the oblique wing airplane have been successfully completed. In total, 39 flights were performed. Two pilots participated in the flights devoted to the pilot evaluation of the flying qualities.

The wing vibration problem previously reported was completely analyzed through ground vibration tests, analysis, and flight tests. From this information, it was determined that the vibration was nothing more than a low amplitude, low damped, limit cycle oscillation inherent in the test airplane in the wing sweep range from 15° to 25°. The phenomenon appeared to be characteristic of the structure and not related to sweeping the wing to an oblique angle.

The flight aerodynamics and handling qualities were evaluated over the entire wing sweep range to 60°, but principally in the region from 35° to 60°. Aerodynamic static and dynamic derivatives were extracted from the flight data to fine-tune the ground-based simulation. The simulation was compared with the airplane's flight characteristics and used to extend the program to evaluate the flying qualities that might be attained through improved control system technology. At wing sweep angles up to 50° the flight characteristics were acceptable to the pilots. Beyond this angle, the piloting task was very demanding; however, in the simulator it was demonstrated that the incorporation of artificial pitch and roll damping in the control system could considerably improve the vehicle's flying qualities.

In conjunction with the flying qualities evaluation, a preliminary assessment was made of the effects of the wing's aeroelasticity on the vehicle's stability characteristics. The AD-1 wing structure was designed to have a specific bending and torsional deflection at the design cruise condition. Ground loads tests verified the design specifications for this condition, and the flight data, through the lateral trim requirements, further served to demonstrate the influence of aeroelasticity and the degree to which the desired bending and torsional deflections may be achieved.

Subsequent flights with the airplane will be devoted to checking out additional pilots to expand the operational experience data base with this unconventional airplane configuration. (Weneth Painter, ext. 238)



Avionics and Flight Control Systems Technology

Synthetic Sensor/Analytic Redundancy Management.— Flight tests have been completed on an analytic redundancy technique which was designed to provide high integrity fail-operational capability at the dual sensor level in redundant digital fly-by-wire (DFBW) control systems. An experimental algorithm to isolate flight control sensor faults between two devices was implemented on the F-8 DFBW aircraft to execute in parallel with the basic F-8 sensor redundancy management software.

The fault isolation process involves a comparison between each sensor of a suspect pair and an estimate of the correct sensor value based on independent, dissimilar, and unfailed sensors. The analytic redundancy management (ARM) algorithm was designed to detect and isolate failures in 12 sensor types; the longitudinal accelerometer, normal accelerometer, lateral accelerometer, roll rate gyro, pitch rate gyro, yaw rate gyro, pitch attitude gyro, roll attitude gyro, directional gyro, altimeter, Mach meter, and angle-of-attack vane. The output of the single sideslip vane was used for some cases.

Four types of analytic redundancy are utilized by the algorithm. Rotational kinematics relates the integrated outputs of the rate gyros and the outputs of the attitude gyros. Altitude kinematics relationships exist between the altimeter output and the second integral of the resolved accelerometer outputs. Translational kinematics relates the integrated output of the accelerometers, vertical gyros (pitch and roll), and rate gyros with the outputs of the air data sensors—Mach meter, altimeter, and angle-of-attack and angle-of-sideslip vanes. Translational dynamics relates the aerodynamic forces on the aircraft as measured by accelerometers and the calculated aerodynamic forces based on air sensor outputs and stored estimates of aerodynamic coefficients. A sequential probability ratio test (SPRT) is performed on the difference of measured and synthesized sensor signals to provide high integrity fault isolation along with false alarm immunity.

During one flight, an actual hardware fault occurred in one angle-of-attack vane during ARM operation. The fault was detected and isolated correctly by the ARM algorithm. The figure below shows the two vane signals and the SPRT signature for each vane. Angle-of-attack residuals are computed as the difference between normal acceleration as computed from aerodynamic forces using stored aircraft lift and drag coefficients and acceleration as measured by the normal accelerometers. The baseline F-8 DFBW sensor fault detection algorithm detected the vane fault several seconds later, when an absolute error of 4° persisted for 100 milliseconds.

Another positive result was noted when no permanent fault was declared during flight operations in moderate buffet during maneuvers at angles of attack above 18°, which produced pitch rate gyro oscillations of 4 degrees per second in the 6- to 10-hertz frequency range.

In addition, fault isolation times have been measured and used to verify predictions based on analytic relationships. Isolation time predictions for the pitch rate gyro are shown in the second figure below. Bias failure magnitude (BFM) is the bias value in the likelihood ratio test. The ratio of inserted fault magnitude to BFM is a sensitive parameter in fault isolation time. (Kenneth Szalai, ext. 347)

IN - FLIGHT ANGLE - OF - ATTACK VANE FAULT ISOLATED BY ARM ALGORITHM

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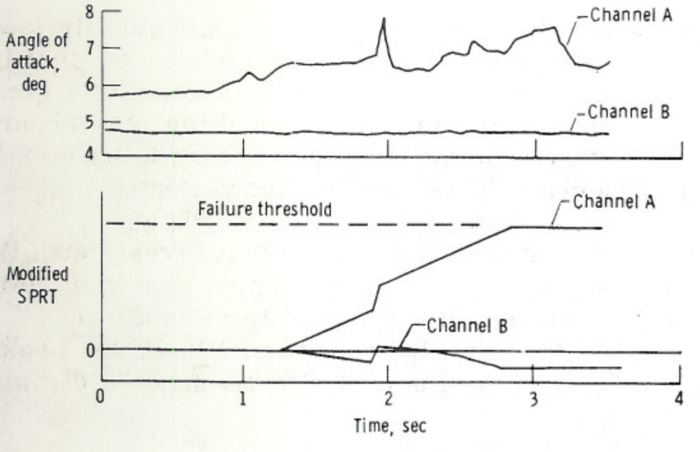

FAULT ISOLATION TIME WITH PITCH RATE GYRO WITH BIAS FAILURE MAGNITUDE OF 1.5 TIMES BFM

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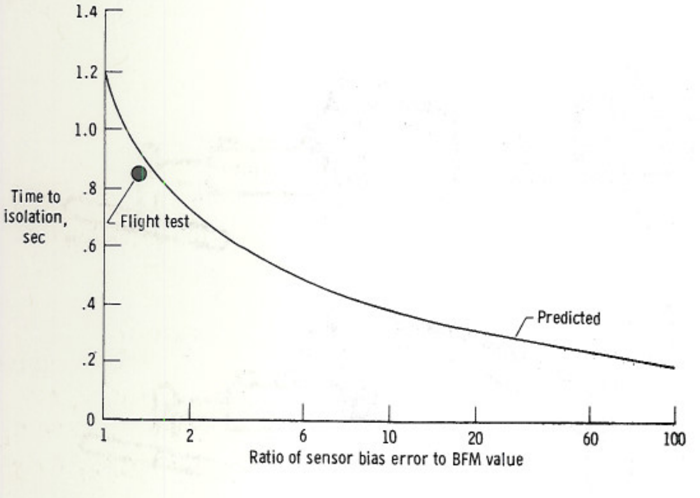
DFRF 81-667

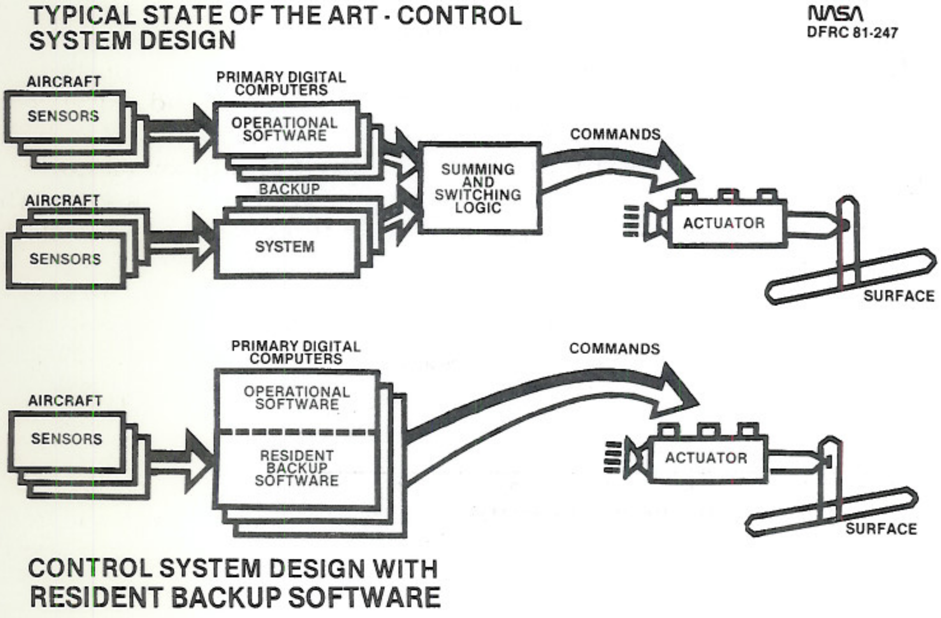


Resident Backup Software Technology.— State-of-the-art primary flight control system designs that employ digital computers are at least triply redundant. The operational software resident in the primary computers is subjected to extensive testing prior to release for flight use. Even though the operational software is subjected to verification and validation testing to minimize undiscovered software faults, some generic faults may remain in the computer program. When an undetected generic fault occurs, as a worst case condition it could result in the simultaneous loss of all digital aircraft control channels. Because of this uncertainty, a separate and independent backup system is incorporated in current digital fly-by-wire control system designs. The backup system is either an analog system or a separate digital computer with different operational software.

One way to reduce the complexity of this type of design (and consequently lower its overall cost) is to incorporate a separate software package which is resident in the primary flight control system computers. Such software is independently generated and is called upon when a generic software anomaly occurs making the primary software suspect. The successful use of the resident backup software is by no means a simple or obvious extension of present software systems technology.

The resident backup software technology experiment at Dryden investigates the initialization, transfer characteristics, and overall system implementation and integration of a resident backup software system with the operational software. Successful completion of this task will eliminate the need for a dissimilar backup system in future designs, and greatly increase the cost effectiveness of digital fly-by-wire systems.

A resident backup software package for NASA's F-8 digital fly-by-wire aircraft has been developed and successfully tested on a ground-based iron bird simulator. Testing included the interjection of numerous generic software faults and verification of detection and reconfiguration without the benefit of a dissimilar hardware backup system. Flight tests of the software are scheduled for the future following additional ground tests. (Calvin Jarvis, ext. 237)

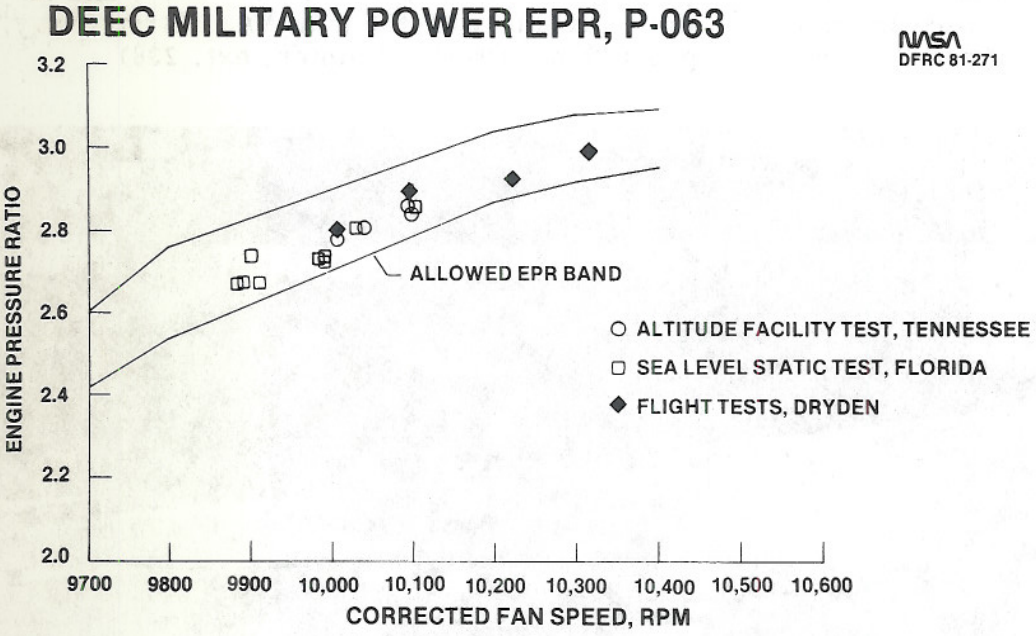


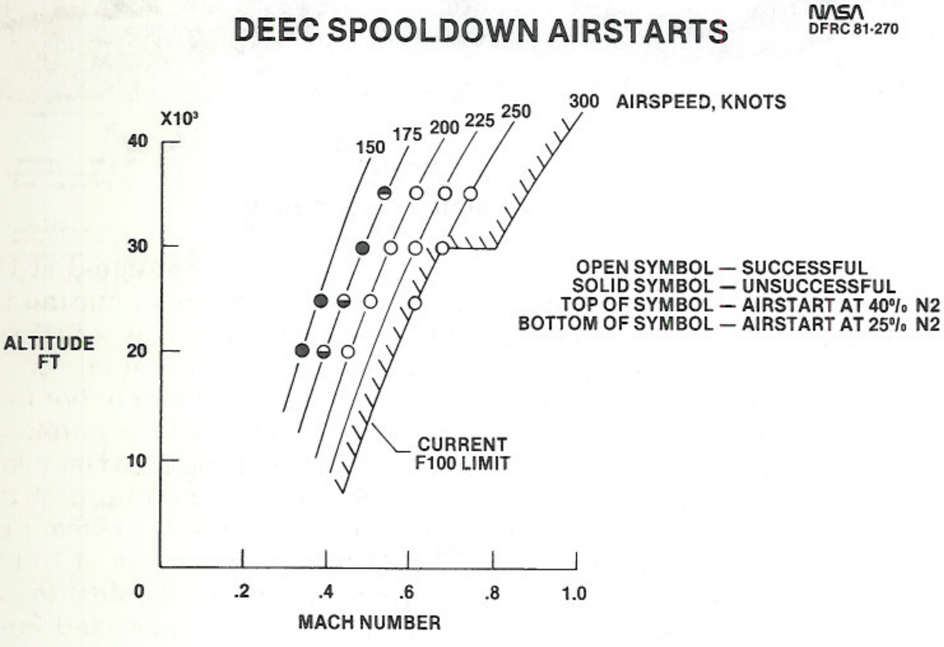
Low-Speed Systems Technology

Flight Test of the Tilt Rotor Research Aircraft.— A joint Ames/Dryden flight test team conducted proof-of-concept flight testing of the XV-15 tilt rotor research aircraft (TRRA) at Dryden in FY 1981 in support of the Ames Research Center TRRA program. The XV-15 aircraft #2 was delivered to Dryden on August 13, 1980 from Bell Helicopter Textron in Arlington, Texas. The aircraft was reassembled and checked out, and the first flight was made at Dryden on October 3, 1980. Sixteen Government acceptance flights were completed on October 30, 1980. The XV-15 aircraft #1 arrived at Dryden on March 5, 1981, and seven research flights were made before the aircraft was shipped to the Paris Airshow. In total, 51 flights were made at Dryden on the two aircraft during the period from October 1980 to May 1981, and all test objectives were accomplished in accordance with the joint NASA/Army/Navy/Proof-of-Concept and Evaluation Program Plan. (Weneth Painter, ext. 238)

High-Speed Systems Technology

Digital Electronic Engine Control.— Flight tests have been conducted at Dryden on an F-15 testbed airplane equipped with an F-100-PW-100 turbofan engine incorporating a digital electronic engine control (DEEC) system. DEEC is a full authority electronic engine control system which is engine mounted and fuel cooled. It incorporates an integral hydromechanical backup control and extensive fault detection and accommodation. The objectives of the flight tests were to 1) evaluate a full authority electronic engine control, 2) demonstrate the engine no-trim control logic, 3) show improved augmentor operation at low Mach numbers and high altitude, and 4) demonstrate an improved air start capability. To date, DEEC system performance has been excellent. The engine pressure ratio (EPR) control mode of DEEC has eliminated the need to periodically retrim or adjust the control system to remain within limits. The figure below shows a plot for EPR versus corrected fan speed at sea level static testing in Florida, altitude cell testing in Tennessee, and flight testing at Dryden. All the data fall well within the expected band. All augmentor test points have been successfully completed, and the operation of the backup control system has been evaluated. One sensor hardware failure occurred, and it was detected and accommodated with no loss in performance. The second figure below shows the results of the air start evaluation, indicating a 50 knot improvement from the standard F-100 engine. Further testing is planned to evaluate improved augmentor software and hardware, including a capability for partial power augmentation. A successful demonstration of the DEEC would provide to NASA a digital engine control capability for programs that require propulsion/flight control integration. (Lawrence Myers, ext. 501)





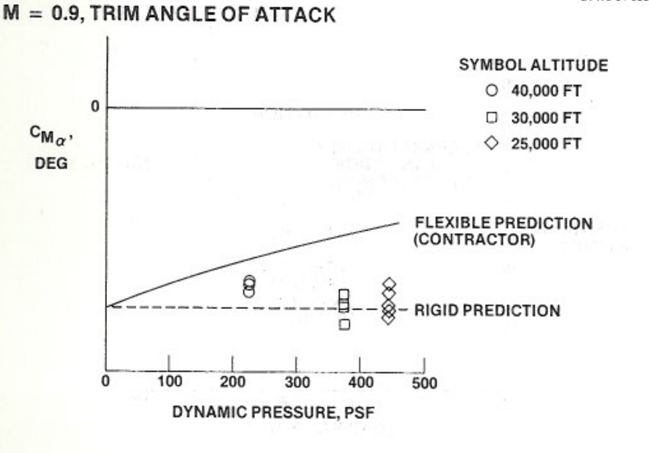
Highly Maneuverable Aircraft Technology.— Both highly maneuverable aircraft technology (HiMAT) remotely piloted research vehicles (RPRV's) have now been flown at the NASA Dryden Flight Research Center. Flight test data have been gathered in the areas of stability and control, flight controls, structures, flutter, and propulsion. Predicted improvements in aerodynamic performance are enhanced by the composite structure and the built-in aeroelastic characteristics of the composites. Initial data analysis of the effect of aeroelasticity on the vehicles' stability characteristics is shown in the first figure. Contrary to predictions, the pitch stability of the vehicle does not become significantly degraded by structural aeroelasticity as dynamic pressure increases at constant Mach number. In general, vehicle stability at all Mach number conditions tested agrees better with rigid than with flexible predictions, which indicates that the methods used to predict aeroelastic effects are not yet well understood.

Preliminary measurements of the HiMAT's outer wing and canard in-flight deflections have also been made. The deflection measurements were made to evaluate the aeroelastic tailoring design methods for enhanced maneuver performance. The second figure shows streamwise twist and deflection data of the outer wing panel taken at Mach 0.8 at various load factors compared to the 8g maneuver design condition at Mach 0.9. Some general observations concerning the agreement of the flight and predicted data can be made even though the flight condition, center-of-gravity position, and lift coefficient are not the same. The nonlinearity of the tip deflection flight data shows about 2 inches less deflection that predicted, which suggests that the twist (calculated from the deflection data) may be about 2° less than predicted at the maneuver design condition. Wing bending moment data shown in the third figure may provide an explanation for the reduced wing panel deflections.

Wing and canard flight loads data have been measured with increasing load factor up to 8g's at transonic Mach numbers. Analysis of wing bending data shows a nonlinearity at about 5g's and above up to 8g's. Analysis of in-flight tuft data indicates the regions of flow separation to be on the outer wing trailing edge and tip fin at these flight conditions, which tends to support the reduced wing deflection and twist results. Even though the flight loads and deflections are less than predicted, preliminary flight data indicate that maneuvering performance is not significantly degraded. (Paul Loschke, ext. 754)

HiMAT AEROELASTIC EFFECTS ON PITCH STABILITY

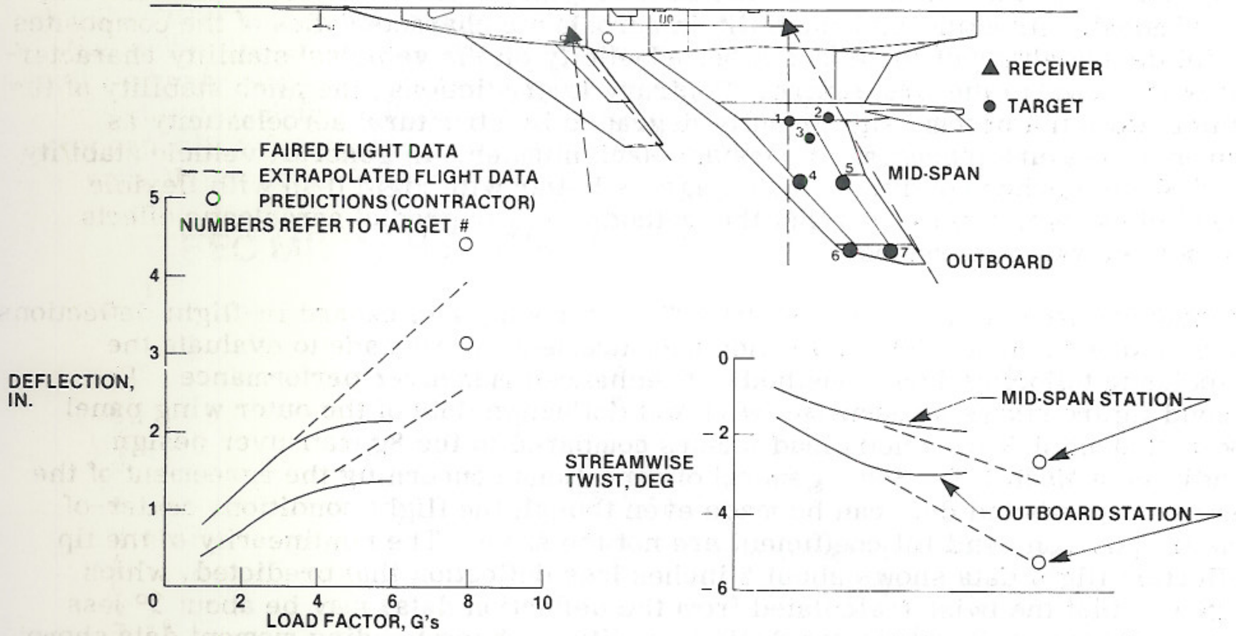
M = 0.9, TRIM ANGLE OF ATTACK



HiMAT WING PANEL DEFLECTIONS AND TWIST

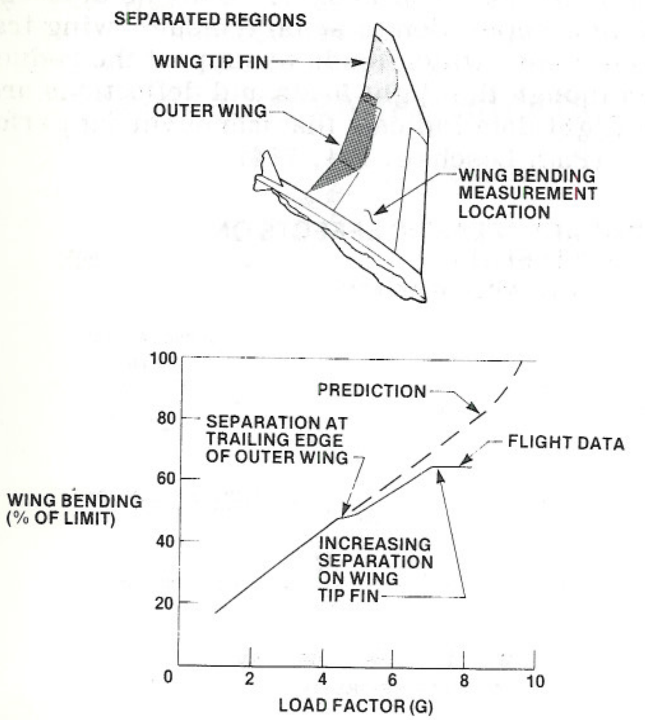
NASA
DFRC 81-359

**NOTE: PRELIMINARY FLIGHT DATA AT 0.8 MACH; 25,000 FT ALTITUDE
PREDICTION AT 0.9 MACH; 25,000 FT ALTITUDE**



HiMAT STRUCTURAL LOADS

NASA
DFRC 81-220



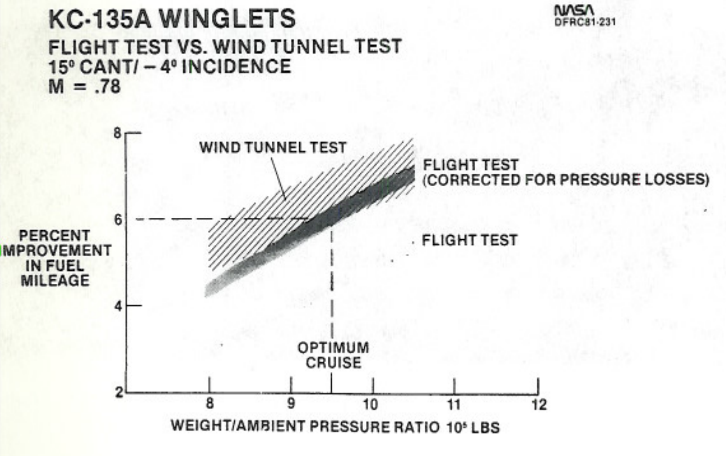
Winglets Program.— Winglets are small, nearly vertical aerodynamic surfaces which are designed to be mounted at the tips of aircraft wings. They are found in nature on all soaring birds, which cant their tip feathers when they maximize lift.

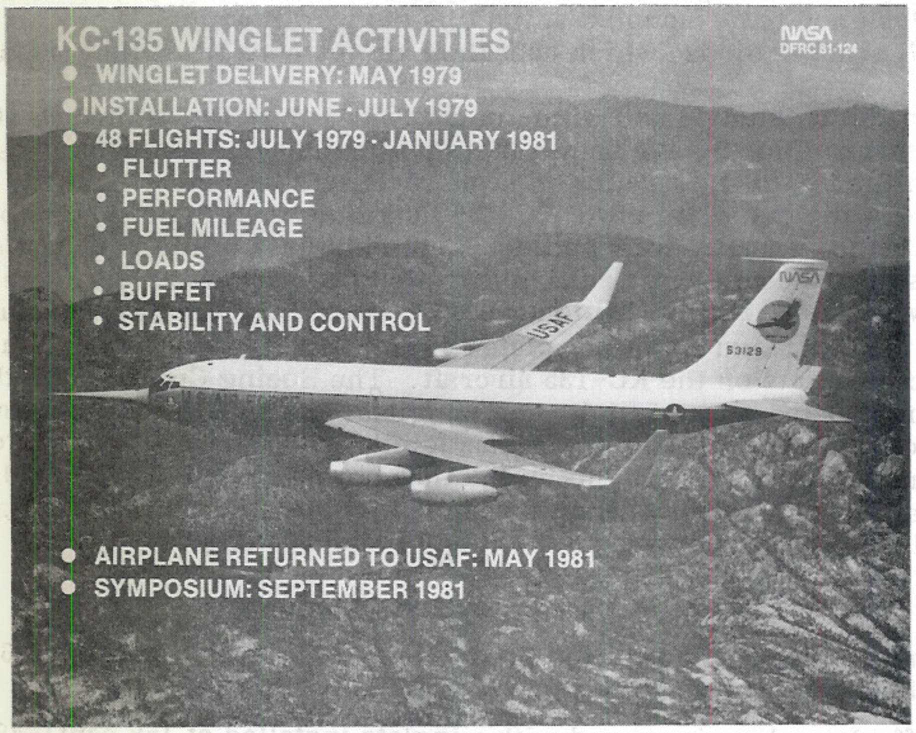
Design optimization studies and wind-tunnel tests led by Dr. Whitcomb of the NASA Langley Research Center have shown that these extensions can produce significant increases in the lift-to-drag ratios on some of today's transport aircraft. The application of winglets to the USAF KC-135 tanker aircraft is predicted to increase its cruise lift-to-drag ratio by 8 percent. This increase would result in an average fuel savings of 60,000 gallons per airplane per year. If retrofitted to the KC-135 fleet, fuel worth more than $1 billion could be saved over the next 20 years. Therefore, the USAF and NASA completed a joint flight program to obtain a full-scale evaluation of winglets on the KC-135 aircraft. The Boeing Company, under USAF contract, constructed a set of flight-test winglets. NASA Dryden instrumented a test airplane and conducted the flight program jointly with the USAF Flight Test Center. The program consisted of 48 flights in the time period from July 1979 to January 1981. The relatively large number of flights resulted from the fact that the winglets tested had several configurations (various cant and incidence angles).

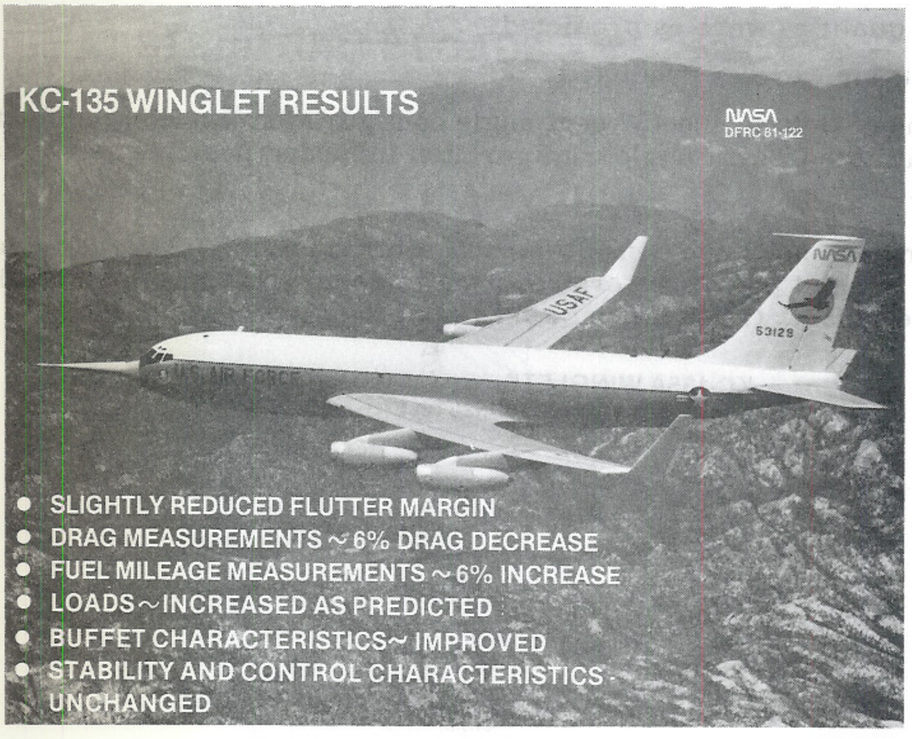
The results of the program can be summarized as follows:

- The performance of the selected production configuration improved 6 percent. Agreement between theory, wind tunnel, and flight test was good.
- The buffet boundary improved with winglets installed at 15° cant/-4° incidence and degraded slightly at 15° cant/-2° incidence.
- Flying qualities were as predicted.
- Flight loads were as predicted.
- In terms of flutter, the 15° cant angle configuration was cleared for flight. Low damping with the 0° cant angle configuration indicated possible aerodynamic separation.

The test airplane has been demodified and returned to the USAF. The results of the KC-135 winglet program were reported in detail at a symposium held at Dryden in September 1981. (Russ Barber, ext. 275)



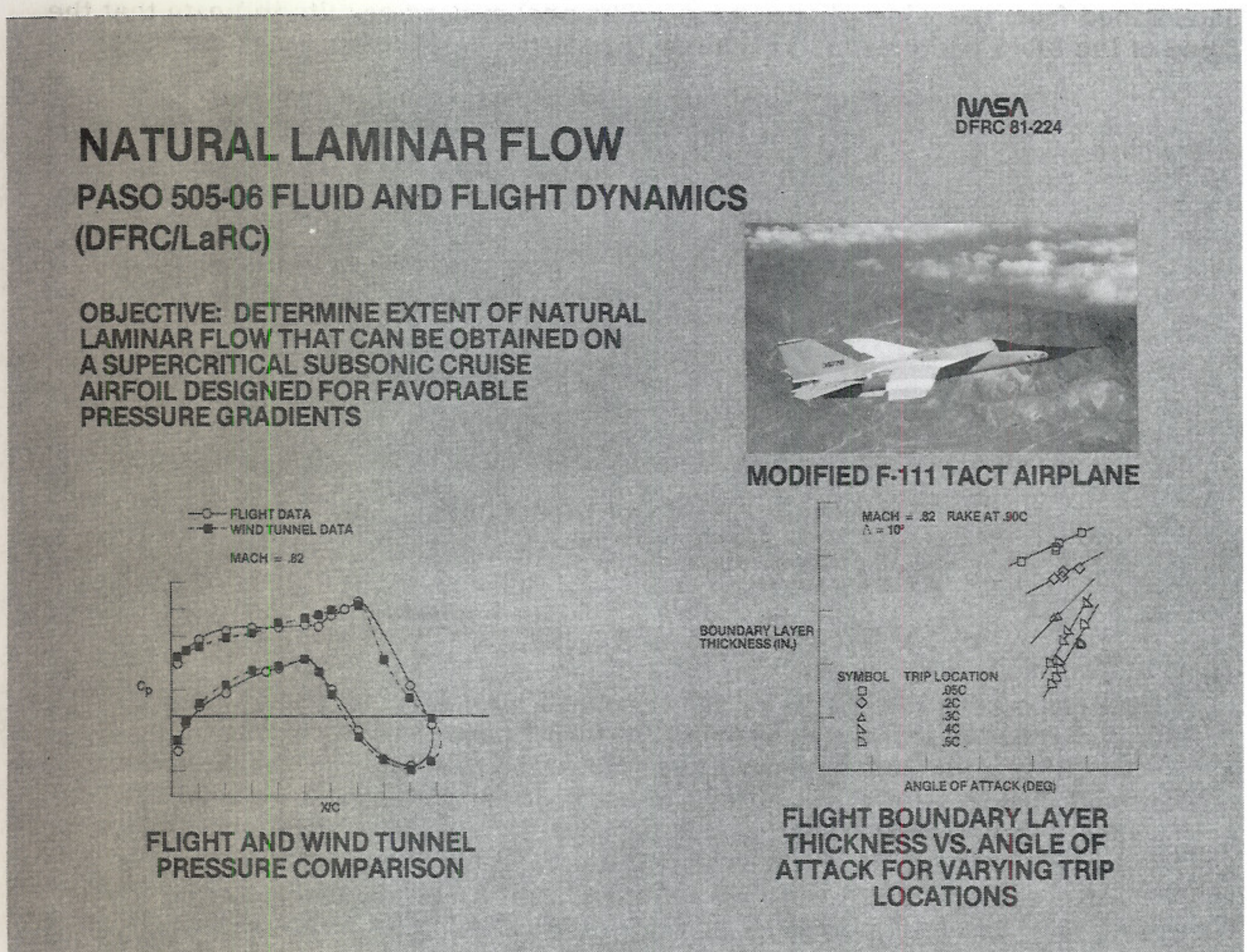

KC-135 WINGLET ACTIVITIES
NASA
DFRC 81-124
WINGLET DELIVERY: MAY 1979
INSTALLATION: JUNE - JULY 1979
48 FLIGHTS: JULY 1979 - JANUARY 1981
FLUTTER
PERFORMANCE
FUEL MILEAGE
LOADS
BUFFET
STABILITY AND CONTROL
AIRPLANE RETURNED TO USAF: MAY 1981
SYMPOSIUM: SEPTEMBER 1981
USAF
NASA
53129


KC-135 WINGLET RESULTS
NASA
DFRC 81-122
SLIGHTLY REDUCED FLUTTER MARGIN
DRAG MEASUREMENTS ~6% DRAG DECREASE
FUEL MILEAGE MEASUREMENTS ~6% INCREASE
LOADS ~ INCREASED AS PREDICTED
BUFFET CHARACTERISTICS ~ IMPROVED
STABILITY AND CONTROL CHARACTERISTICS - UNCHANGED
USAF
NASA
53129

Natural Laminar Flow Experiment.— A joint Dryden/Langley experiment was initiated under the energy efficient transport element of the aircraft energy efficiency (ACEE) program to evaluate the extent of natural laminar flow that could be achieved in a real flight environment over a wing chord approximately 10 feet in length. The experiment consisted of 19 flights and was conducted on the F-111 transonic aircraft technology (TACT) airplane modified with a natural laminar flow (NLF) airfoil glove section. The section consisted of a supercritical airfoil, which provided favorable pressure gradients over extensive portions of the upper and lower surfaces while generating useful lift coefficients.

Pressure distribution and boundary-layer measurements augmented by oil flow photographs were used to define the extent of laminar flow and the section performance characteristics in flight. These techniques were applied for a range of forced transition locations over the test chord and, of course, for the clean natural transition condition. The F-111 TACT testbed airplane permitted the leading edge sweep angle to vary from 10° to 26° at Mach numbers from 0.80 to 0.85 and chord Reynolds numbers from about 25×10^6 to 30×10^6.

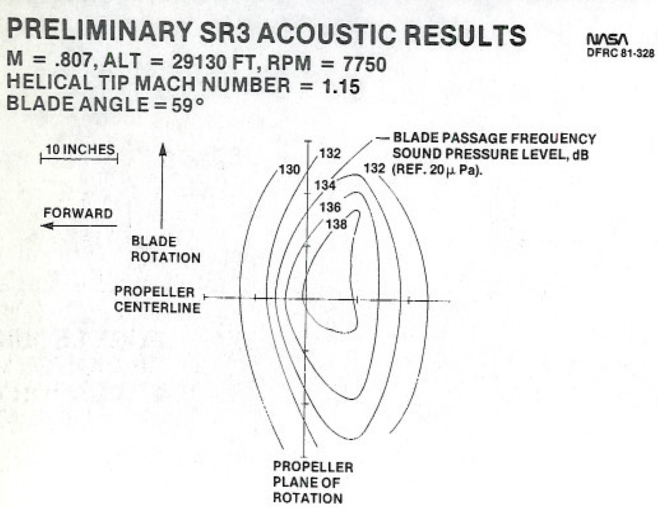
Preliminary data analysis indicates that natural laminar flow was maintained over a large portion of the test section. (Larry Montoya, ext. 423)



Advanced Turboprop Flight Research.— As part of the NASA aircraft energy efficiency program, a joint Dryden/Lewis research effort is being conducted to investigate the near-field acoustic characteristics of a series of subscale advanced design propellers. Currently, a series of these propellers are being flight tested on the Dryden JetStar airplane. The results of these subscale propeller tests are required to establish near-field acoustics and provide design information for full-scale flight testing.

The JetStar airplane has been modified with the installation of an air drive system and an air turbine drive motor. The motor and propellers are pylon mounted on top of the fuselage of the JetStar airplane as shown in the figure below. An array of flush mounted microphones is located on the fuselage under the propeller.

The first phase of the flight testing on one advanced propeller design, SR-3, has been completed. In the second figure below, preliminary sound spectrum data show the blade passage frequency and its harmonics. Noise measurements made without the propeller are also shown and indicate that the boundary layer noise and the noise produced by the JetStar engines is well below the propeller noise level. Additional data show the blade passage frequency sound pressure level contours determined from the microphone array. The preliminary results indicate that the noise of the SR-3 propeller is lower than predicted. (Paul Lasagna, ext. 364)

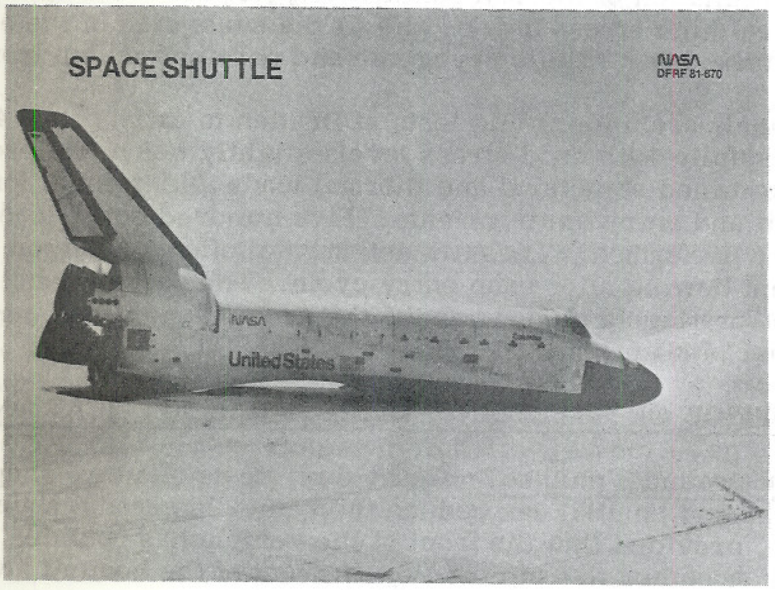


SPACE RESEARCH AND TECHNOLOGY BASE

Aerothermodynamics Research and Technology

Space Shuttle Stability and Control Derivatives.— Flight estimates of the space shuttle stability and control derivatives are required in order to assure the safe routine operation of the vehicle. Although the first shuttle flight included no maneuvers for the purpose of estimating stability and control derivatives, some estimates were obtained from maneuvers performed for other purposes.

This analysis demonstrated the ability to estimate derivatives from hypersonic flight data for a large manned winged entry vehicle. Extremely small dynamic motions were successfully analyzed because of the high resolution instrumentation package. The general trends of the shuttle derivative predictions were validated. The greatest disagreement with predictions was found in the reaction control system jet aerodynamic interaction effects. Good lateral-directional results were difficult to obtain below a Mach number of 3 because of wind shear, buffet, and linear dependence problems. In order to further validate the predictions, specific stability and control maneuvers will need to be performed in critical areas of the flight envelope on subsequent flights. (Kenneth Iliff, ext. 724)



Materials and Structures Research and Technology

Heated Built-up Structure.— A joint Dryden/Langley effort has been completed which centered around heating tests of three built-up structures constructed of various combinations of beryllium, titanium, and stainless steel alloys. The unique high temperature testing capabilities at Dryden were used to acquire thermoelastic test data basic to evaluating thermal stress prediction methods. The laboratory heating tests consisted of simulating high Mach number heating on the three frame/skin specimens: 1) a titanium truss frame with a Lockalloy skin, 2) a stainless steel frame with a Lockalloy skin, and 3) a titanium Z-frame with a Lockalloy skin. Strains, temperatures, and deformations were measured on these three specimens for the purpose of examining their efficiency, performance, and integrity. Measured thermal stresses are being examined with respect to material yield strengths, buckling criteria, structural weight, and geometric location. Principal thermal stresses are being studied from the point of view of uniaxial and biaxial stress assumptions. Measured thermal stresses are being compared to predicted values using the NASTRAN finite element computer program. Calculated temperatures based on a thermal model (NASTRAN) with conduction, radiation, and convection features have been compared to measured spar temperatures. All modes of heat transfer (conduction, radiation, and convection) were shown to significantly affect the magnitude and distribution of structural temperatures. (Jerald Jenkins, ext. 454)

René 41 Honeycomb Panel Tests.— One concept for a single-stage-to-orbit vehicle employs an integral tank/fuselage structure which combines the functions of fuel containment, thermal protection, and support of vehicle thrust and aerodynamic loads. The structure consists of a honeycomb sandwich with the outer skin exposed to the aerothermal environment. The proposed entry trajectory dictates maximum surface temperatures of 1400° F, which is within the operating range of René 41. A coordinated effort between Langley, the Boeing Aerospace Company, and Dryden has addressed 1) the development of an acceptable fabrication method for René 41 honeycomb sandwich, 2) the development of preliminary structural design allowables data, 3) the determination of thermal conductivity, 4) the assessment of combined thermal/mechanical high stress levels, and 5) the evaluation of the effect of stress-relieving slots in the outer skin to cryogenic and aerothermal environments.

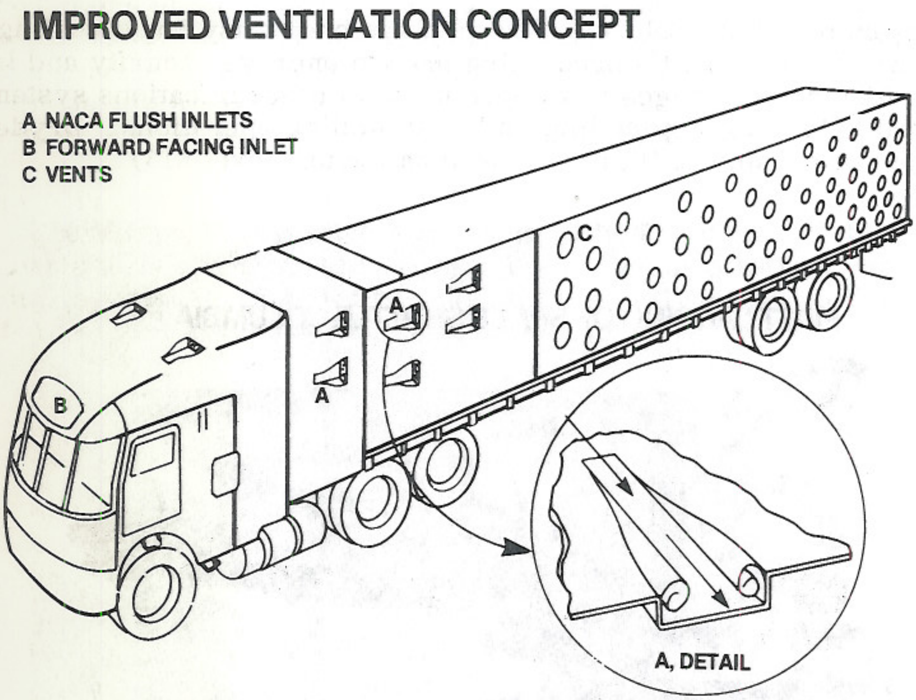
Two 12" X 72" panels are undergoing tests at Dryden to satisfy item 4) above. The first panel successfully withstood stress levels slightly below the proportional limit resulting from combined structural and thermal loads under conditions duplicating the boost-to-orbit and entry environments. Five hundred boost-to-orbit and 500 entry cycles were performed. The only detrimental effects noted on the panel was a slight permanent bowing after each entry cycle. The second panel is currently being tested at stress levels slightly above the proportional limit. (Roger Fields, ext. 748)

OFFICE OF SPACE AND TERRESTRIAL APPLICATIONS

Aerodynamics of Ground Vehicles.— Coast-down tests of a box-shaped vehicle have shown that a truncated boattail can reduce the vehicle's aerodynamic drag by about 30 percent, provided that the front of the vehicle has rounded corners and the underbody is smoothed to keep the flow in front of the boattail attached. The drag coefficient of the vehicle with rounded front corners and the truncated boattail is about 0.31, which is lower than the drag coefficients of most foreign or domestic sports cars.

The results of the ground vehicle experiments completed during FY 81 are reported in NASA CR-163104, NASA CR-163107, NASA CR-163111, and NASA CR-163113.

One-year grants have been issued to the California Polytechnic State University at San Luis Obispo, California and the University of Kansas at Lawrence, Kansas. These grants are intended to fund wind-tunnel tests on models of conventional livestock hauler trucks and on a new concept for a livestock hauler with positive ventilation and temperature control. The Science and Education Administration of the U.S. Department of Agriculture is assisting in the funding of this effort. The new concept of improved ventilation has been proposed as a partial answer to the problem of "livestock shipping fever," or bovine respiratory disease, which causes an annual economic loss over $400 million. A sketch of a candidate version of the improved ventilation concept is included. (Edwin Saltzman, ext. 378)



OFFICE OF SPACE TRANSPORTATION SYSTEMS

Space Shuttle Orbital Flight Test.— The past year has been an eventful one for the space shuttle at Dryden. The major events marking this year were the completion of the orbiter support facilities, completion of plans and rehearsals for the landing of the orbiter, the historic first landing of the orbiter Columbia, and post flight processing and ferry of the Columbia to Kennedy Space Center. Since then, we have been applying the lessons learned from the first flight to facility and operational changes to make operations for the second flight smoother and more efficient.

Prior to the first flight, Dryden accomplished a number of detail changes to the mate demate device and the shuttle hangar to prepare them to receive and deservice the orbiter. The extensive communications systems required for the landing, post landing, and television/public affairs operations were completed and checked out.

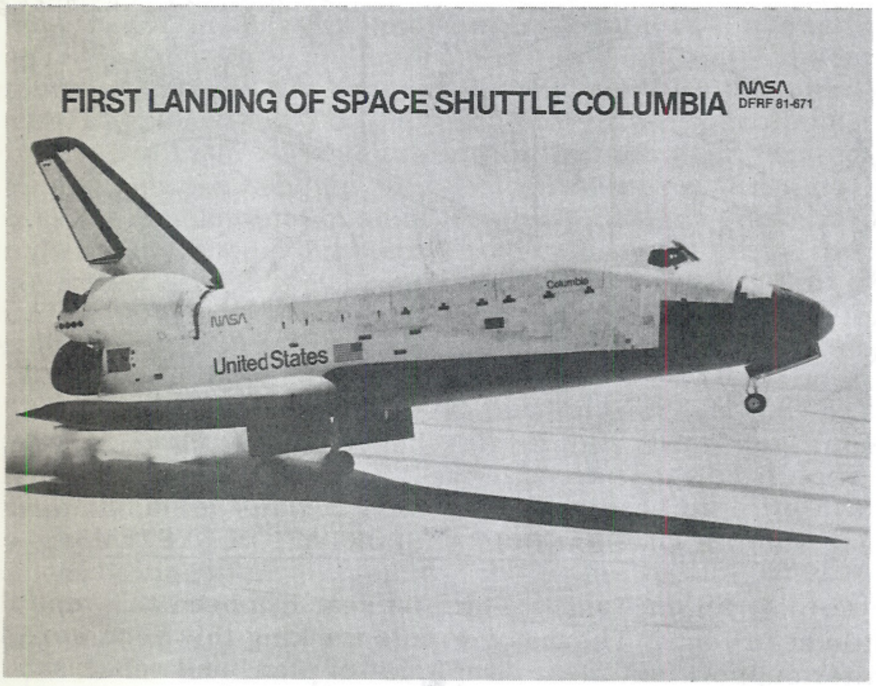
Dryden and the Kennedy Space Center were also involved in checking out and modifying the ground support equipment for the orbiter.

Elements of the Kennedy, Johnson, Dryden, and Department of Defense landing team assembled on site for a number of operations rehearsals in the month and one-half prior to flight.

The historic first landing of the Columbia took place at Dryden on April 14. The event was witnessed by over 100,000 VIP and special guests, 1,500 members of the press, and 300,000 general public visitors.

Post flight safing of the Columbia and preparations for flight back to Kennedy were completed in 13 days.

Since the departure of the Columbia, Dryden has been busy implementing a number of detail changes to the shuttle processing area to improve security and improve operations. Also some changes have been made in communications systems to improve coordination during landing and post landing operations. Dryden is now ready for the second shuttle flight. (Garrison Layton, ext. 613)



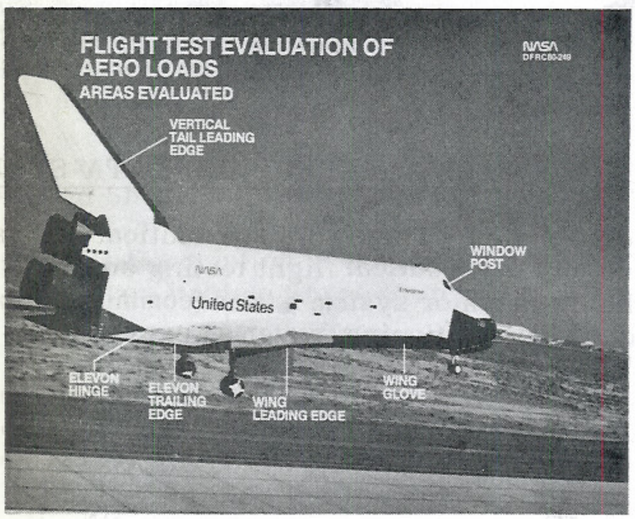
<u>Shuttle Thermal Protection System Airloads Flight Test Program</u>.— Flight tests to determine the effects of airloads on the space shuttle orbiter thermal protection system (TPS) were conducted at the NASA Dryden Flight Research Center. Several areas of the TPS on the orbiter were identified for flight test evaluation. For each area, test specimens were constructed to simulate the full-scale vehicle outer mold lines and geometric shape. Production TPS tiles and gap fillers were used and installed in accordance with the production specifications currently employed to install the same elements on the OV-102 orbiter vehicle.

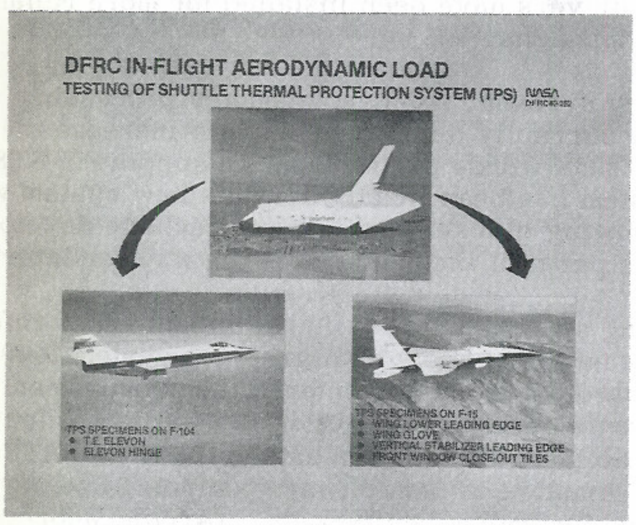
The test specimens were then mounted on F-15 and F-104 research aircraft in an attempt to simulate the local flow conditions existing on the orbiter. These aircraft were selected because of their ability to achieve the high speed and high dynamic pressures required to simulate the shuttle launch environment.

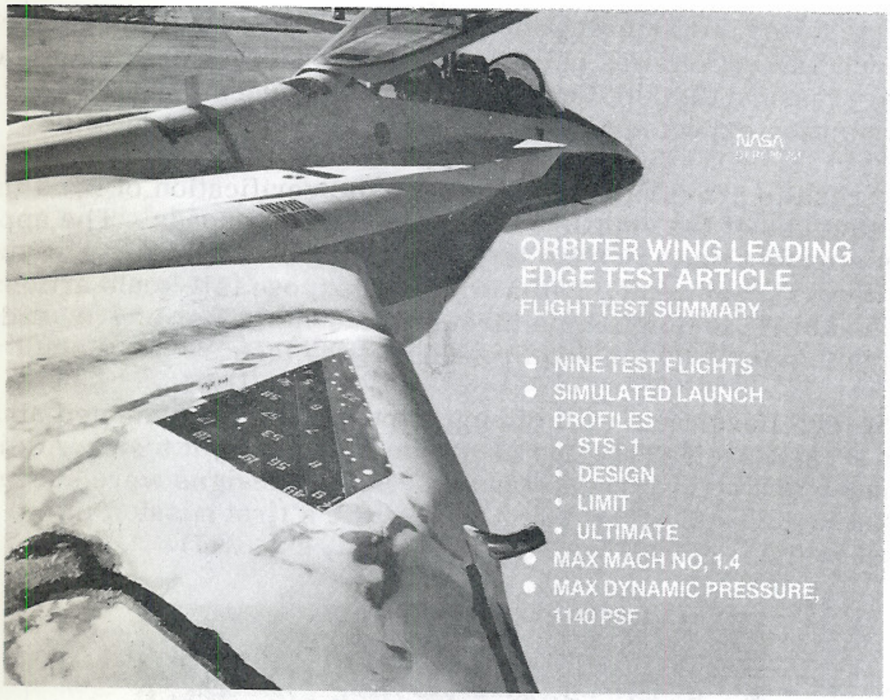
In attaching the test specimen to the aircraft, each specimen was configured to the outer mold line curvature of the orbiter, with fiber glass fairings or ramps used to blend the article to the surrounding aircraft surface. Pressure instrumentation installed on each test article was used to measure local flow on the aircraft and to verify that the pressure distribution on each test specimen approximated the pressure distribution expected on the orbiter in the region under study.

The flight test results provided a data base for the verification of wind tunnel and analytical predictions of the shuttle's TPS response to airloads. The approach was expedient and effective due to 1) the large Mach number/dynamic pressure envelope of the carrier aircraft, 2) the ability to expose full-scale articles to realistic airloads, 3) the ability to obtain data through a Mach number of 1.0, and 4) the ability to respond quickly to the requirements of the tests.

In general, the TPS performed well during exposure to the simulated airloads; however, two areas were redesigned as a result of the flight tests. Additional flight testing at ultimate test conditions showed that both redesigns were successful. No TPS failure due to airloads occurred on the shuttle's first mission in the areas that were evaluated in the flight tests. (Calvin Jarvis, ext. 237)







OFFICE OF SPACE TRACKING AND DATA SYSTEMS

NASA Aeronautical Test Range.— The NASA aeronautical test range (ATR) is continuing to evolve to meet the aeronautical flight testing and research requirements of the future. All of the three major system areas (communications systems, ground telemetry systems, and space positioning systems) experienced growth in FY 81.

In the communications systems area, a microprocessor-based remote channelization system has been installed for automated radio frequency selection from the mission control centers. The range communications system (RACOM) has been modified extensively for the first and second shuttle flights (STS-1 and STS-2). The ATR video distribution network has undergone numerous modifications to support STS-1 and STS-2. New line drivers have been installed for more reliable, lower maintenance support of all missions.

In the ground telemetry systems, two new telemetry processing systems (TPS) have been accepted and are currently being developed to increase the telemetry handling capability from 64K to 200K words per stream. In support of STS-1, a new real-time FORTRAN display system has been installed. This new system will benefit all real-time users by allowing quicker applications package development and more real-time computations per unit time and paves the way for interactive user inputs.

In the space positioning systems area, fully redundant radar information and display system processors are now operational. A graphics system to eventually replace the mechanical plot boards of today has entered the procurement cycle. Finally, a replacement for the hardwired target acquisition and data collection (TACDAC) system is under contract. The new radar data system (RADATS) will be microprocessor based and formatted under software control, allowing for responsive, flexible reconfiguration for radar data formats. (Archie Moore, ext. 482)

TECHNICAL REPORTS, PAPERS, AND ARTICLES

FY 1981

REPORTS BY DRYDEN PERSONNEL

1. Jenkins, Jerald M.: The Effect of Thermal Stresses on the Integrity of Three Built-up Aircraft Structures. NASA TM-81352.

2. Maine, Richard E.; and Iliff, Kenneth W.: User's Manual for MMLE3, A General FORTRAN Program for Maximum Likelihood Parameter Estimation. NASA TP-1563.

3. Tang, Ming H.; Sheldon, Robert G.; and Black, Donald C.: A Modified T-Value Method for Selection of Strain Gages for Measuring Loads on a Low Aspect Ratio Wing. NASA TP-1748.

4. Quinn, Robert D.; and Gong, Leslie: In-Flight Boundary-Layer Measurements on a Hollow Cylinder at a Mach Number of 3.0. NASA TP-1764.

5. Kurtenbach, Frank J.; and Burcham, Frank W., Jr.: Flight Evaluation of a Simplified Gross Thrust Calculation Technique Using an F100 Turbofan Engine in an F-15 Airplane. NASA TP-1782.

6. Ehernberger, L. J.; and Guttman, Nathaniel B.: Climatological Characteristics of High Altitude Wind Shear and Lapse Rate Layers. NASA TM-81353.

7. Monaghan, Richard C.: Description of the HiMAT Tailored Composite Structure and Laboratory Measured Vehicle Shape Under Load. NASA TM-81354.

8. Maine, Richard E.: User's Manual for SYNC, a FORTRAN Program for Merging and Time-Synchronizing Data. NASA TM-81355.

9. Harney, Paul F.: Diversity Techniques for Omnidirectional Telemetry Coverage of the HiMAT Research Vehicle. NASA TP-1830.

10. Carter, Alan L.; and Sims, Robert L.: Comparison of Theoretical Predictions of Orbiter Airloads With Wind Tunnel and Flight Test Results for a Mach Number of 0.52. NASA TM-81358.

11. Jenkins, Jerald M.: A Comparison of Laboratory Measured Temperatures With Predictions for a Spar/Skin Type Aircraft Structure. NASA TM-81359.

12. Redin, Paul C.: Application of a Performance Modeling Technique to an Airplane With Variable Sweep Wings. NASA TP-1855.

13. Larson, Terry J.; and Siemers, Paul M. III: Subsonic Tests of an All-Flush-Pressure-Orifice Air Data System. NASA TP-1871.

14. Weil, Joseph; and Powers, Bruce G.: Correlation of Predicted and Flight Derived Stability and Control Derivatives - With Particular Application to Tailless Delta Wing Configurations. NASA TM-81361.

15. Maine, Richard E.: Programmer's Manual for MMLE3, A General FORTRAN Program for Maximum Likelihood Parameter Estimation. NASA TP-1690.

16. Hughes, Donald L.: Comparison of Three Thrust Calculation Methods Using In-Flight Thrust Data. NASA TM-81360.

17. Maine, Richard E.; and Iliff, Kenneth W.: The Theory and Practice of Estimating the Accuracy of Dynamic Flight-Determined Coefficients. NASA RP-1077.

18. Preliminary Analysis of STS-1 Entry Flight Data. NASA TM-81363.

19. Sims, Robert.: User's Manual for FSLIP-3, FLEXSTAB Loads Integration Program. NASA TM-81364.

20. Ayers, Theodore G.; and Hallissy, James B.: Historical Background and Design Evaluation of the Transonic Aircraft Technology Supercritical Wing. NASA TM-81356.

21. Bauer, Carol A.; Mackall, Karen G.; Stoll, Frederick; and Tremback, Jeffrey W.: Comparison of Flight and Wind Tunnel Model Instantaneous Distortion Data From a Mixed-Compression Inlet. NASA TM-81362.

22. Bauer, Carol A.: Wind Tunnel and Flight Comparison of Instantaneous Distortion Characteristics of a Mixed-Compression Inlet of a YF-12 Airplane. NASA TM-81357.

23. Walker, Harold J.: Analytic Study of Orbiter Landing Profiles. NASA TM-81365.

REPORTS BY CONTRACTOR PERSONNEL

1. Lorincz, Dale J.: Flow Visualization Study of the F-14 Fighter Aircraft Configuration. NASA CR-163098.

2. Kalev, I.: A Computer Program for Cyclic Plasticity and Structural Fatigue Analysis. NASA CR-163101.

3. Radford, R. C.; Smith, R. E.; and Bailey, R. E.: Landing Flying Qualities Evaluation Criteria for Augmented Aircraft. NASA CR-163097.

4. Anderson, D. L.; Connolly, G. F.; Mauro, F. M.; and Reukauf, P. J.: YF-12 Cooperative Airframe/Propulsion Control System Program, Volume I. NASA CR-163099.

5. Bergstrom, R. W.; Doyle, J. R.; Johnson, C. D.; Holman, H. Y.; and Wojcik, M. A.: Assessment of the Visibility Impairment Caused by the Emissions From the Proposed Power Plant at Boron, California. NASA CR-163103.

6. Muirhead, Vincent U.: An Investigation of Drag Reduction for Tractor Trailer Vehicles With Air Deflector and Boattail. NASA CR-163104.

7. Kotsabasis, Alexandros: The DAST-1 Remotely Piloted Research Vehicle Development and Initial Flight Testing. NASA CR-163105.

8. Bangert, L. H.; Feltz, E. P.; Godby, L. A.; and Miller, L. D.: Aerodynamic and Acoustic Behavior of a YF-12 Inlet at Static Conditions. NASA CR-163106.

9. Hartmann, Gary L.; and Stein, Gunter: F-8C Adaptive Control Law Refinement and Software Development. NASA CR-163093.

10. James, Robert: Baseline Mathematics and Geodetics for Tracking Operations. NASA CR-163102.

11. Pihos, Gregory G.; and Wurtele, Morton G.: An Efficiency Code for the Simulation of Nonhydrostatic Stratified Flow Over Obstacles. NASA CR-3385.

12. Muirhead, Vincent U.: An Investigation of Drag Reduction for a Standard Truck With Various Modifications. NASA CR-163107.

13. Teper, Gary L.; Dimarco, Richard J.; Ashkenas, Irving L.; and Hoh, Roger H.: Analyses of Shuttle Orbiter Approach and Landing Conditions. NASA CR-163108.

14. Sandlin, Doral R.: Flight Evaluation of the Terminal Guidance System. NASA CR-163859.

15. Schmidt, David K.; and Innocenti, Mario: Pilot-Optimal Multivariable Control Synthesis by Output Feedback. NASA CR-163112.

16. Muirhead, Vincent U.: An Investigation of Drag Reduction for a Box-Shaped Vehicle With Various Modifications. NASA CR-163111.

17. Peterson, Randall L.: Drag Reduction Obtained by the Addition of a Boattail to a Box Shaped Vehicle. NASA CR-163113.

18. Foote, C. H.; and Jaekel, R. J.: Flight Evaluation of an Engine Static Pressure Noseprobe in an F-15 Airplane. NASA CR-163109.

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1. Andrews, W. H.; Sim, A. G.; Monaghan, R. C.; Felt, L. R.; McMurtry, T. C.; and Smith, R. C.: AD-1 Oblique Wing Aircraft Program. SAE Paper 801180, Aerospace Congress & Exposition Meeting, Los Angeles, California, October 13-16, 1980.

2. Szalai, K. G.; Larson, R. R.; and Glover, R. D.: Flight Experience With Flight Control Redundancy Management. AGARD Lecture Series No. 109, Athens, Rome, London, October 13-21, 1980.

3. Burcham, F. W., Jr.; and Stewart, J. F.: The Development Process for Integrated Propulsion-Flight Controls. Tactical Aircraft Research and Technology Conference, Langley Research Center, October 21-23, 1980.

4. Arnaiz, H. H.; and Loschke, P. C.: Current Overview of the Joint NASA/USAF HiMAT Program. Tactical Aircraft Research and Technology Conference, Langley Research Center, October 21-23, 1980.

5. Borek, R. W.: Practical Aspects of Instrumentation Installation in Support of Subsystem Testing. AGARD Flight Testing of Subsystems and Test Instrumentation Symposium, Geilo, Norway, October 27-31, 1980.

6. Weaver, E. A.; Ehernberger, L. J.; Gary, B. L.; Kurkowski, R. L.; Kuhn, P. M.; and Stearns, L. P.: The 1979 Clear Air Turbulence Flight Tests. NASA Operating Problems Conference, Langley Research Center, November 5-7, 1980.

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9. Jarvis, Calvin R.; and Szalai, Kenneth J.: Ground and Flight Test Experience With a Triply Redundant Digital Fly-by-Wire Control System. Presented at the Advanced Aerodynamics and Active Controls Conference held at the Ames Research Center, Mountain View, California, October 7-9, 1980.

10. Steers, Louis L.: Natural Laminar Flow Flight Experiment. Presented at the Advanced Aerodynamics and Active Controls Conference held at the Ames Research Center, Mountain View, California, October 7-9, 1980.

11. Montoya, Lawrence C.: KC-135 Winglet Flight Results. Presented at the Advanced Aerodynamics and Active Controls Conference held at the Ames Research Center, Mountain View, California, October 7-9, 1980.

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R&T FLIGHT ACTIVITIES SUMMARY

FY 1981

PROGRAM	AIRCRAFT	FLIGHTS
Digital Fly-by-Wire	F-8 #802	20
Winglets	KC-135 #129	8
	DC-10	4
Laminar Flow Control	JetStar #814	9
AFTI P-9 Engine Baseline Tests	F-111 #778	10
Oblique Wing	AD-1 #805	19
Advanced Propeller Tests	JetStar #814	13
High Alpha Tests	F-14 #991	18
DEEC Flight Tests	F-15 #287	7
HiMAT (Captive & Drop Flights)	HiMAT #870	5
	HiMAT #871	5
Spin Research	SRV	19
Tilt Rotor	XV15 #702 (Ames A/C)	7
	XV15 #703 (Ames A/C)	44
PIO Suppressor Investigation	Calspan T-33 #120	8
Test Techniques Development	JetStar #814	1
Innovative Research Experiments	PA-30 #808	2
	F-104 #826	1
Base Drag Study	F-104 #826	13
Remote Piloted Research Support	PA-30 #808	19
Stereo TV Study	PA-30 #808	4
Tornado Drop Model Tests	Heli #734 (Ames A/C)	10
B-52 Research Support	B-52 #008	29
Shuttle Program		
Orbiter Support	B-747 SCA #905	3
Tile Tests	F-15 #281	8
	F-104 #826	6
MSBLS	JetStar #814	55
	Total	347

Note: Accomplishment of these R&T flight activities also requires many supporting flights each year with these and other Center aircraft.

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16. Abstract

This report highlights the research and technology (R & T) accomplishments at the NASA Dryden Flight Research Center in fiscal year 1981. The Dryden Flight Research Center is primarily engaged in conducting flight research into vehicle, systems, piloting, and operational problems. Dryden develops or modifies both piloted and remotely piloted aircraft where necessary for performing flight research. Many Dryden programs are conducted jointly with other NASA installations or Government agencies. Dryden also performs or sponsors supporting research in instrumentation, flight test techniques, piloting, flight systems, guidance, communications, crew functions, and air vehicles.

Fiscal year 1981 has been an active and productive year at Dryden, with activities ranging from support of the space shuttle program to conducting a wide variety of aeronautics programs. The highlight of the year was our participation in the historic first landing of the Columbia at Dryden on April 14, 1981. The results of Dryden R & T work published in fiscal year 1981 in technical reports, papers, and articles are listed in the report, as is a summary of the R & T flight activities.

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